APPLICATION OF LANDSCAPE-SCALE HABITAT SUITABILITY MODELS TO BIRD CONSERVATION PLANNING

Frank R. Thompson III,
USDA Forest Service North Central Research Station, Columbia, MO
Application of landscape-scale habitat suitability models to bird conservation planning

- Review concept of HSI
- Look at historical application
- Adapt HSI to landscape-scale, GIS-based applications for conservation planning
HSI model basics

• Numerical index of habitat suitability on a 0.0 to 1.0 scale
• Models can be based on published knowledge, data, expert opinion
• Documentation explains the model's structure, data sources, and assumptions
• Models should be viewed as hypotheses of species-habitat relationships
• Their value is to serve as a basis for improved decision making and increased understanding of habitat relationships; they specify hypotheses of habitat relationships that can be tested and improved.
Original HSI formulation

\[ HSI = (V1 \times V2 \times V3)^{1/3} \]

\( V1 \ldots Vx \) = limiting factors or life requisites; if any one variable = 0 then \( HSI = 0 \)
USFWS HSI model series


Habitat Suitability Index Models Series

This site contains the 157 Habitat Suitability Index (HSI) models reports published by the US Fish and Wildlife Service, made available as part of the National Wetlands Research Center's digital library collection. All files are in PDF format; we recommend using Adobe Reader to view the files.
HABITAT SUITABILITY INDEX MODELS:
YELLOW WARBLER

Fish and Wildlife Service
U.S. Department of the Interior
Yellow warbler HSI model (USFWS 1982)

\[ HSI = \left( V_1 \times V_2 \times V_3 \right)^{1/3} \]
HSI models for conservation planning

- Applicable to larger scales
- Applicable in GIS
- Utilize available data
- Address concepts of abundance and viability
Adapting HSI models to raster-based GIS

- SIs and HSI values calculated for each pixel
- Results in a new data layers representing maps of SI and HSI values
- SIs can be based on pixel attributes or attributes of surrounding pixels
- Can utilize wide range of GIS functions or landscape statistics
- HSI values can be summarized for the landscape
Acadian flycatcher HSI model (in development)

• $SI_1$: We considered birds to be densest (relative density = 1.000) in mature (Pagen et al. 2002) woody wetlands (Sallabanks et al. 2000) along floodplains and valleys (Klaus et al. 2005) and scarcest in sapling evergreen stands along xeric slopes and ridges.
## Acadian flycatcher $SI_1$

Table 1. Relationship between landform, forest type, age class, and relative density of Acadian flycatchers.

<table>
<thead>
<tr>
<th>Landform</th>
<th>Forest type</th>
<th>Age class</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Floodplain/valley</td>
<td>Woody wetlands</td>
<td>Sapling</td>
<td>0.350</td>
<td>0.700</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Deciduous</td>
<td>Pole</td>
<td>0.315</td>
<td>0.630</td>
<td>0.900</td>
</tr>
<tr>
<td></td>
<td>Mixed</td>
<td>Sawtimber</td>
<td>0.210</td>
<td>0.420</td>
<td>0.600</td>
</tr>
<tr>
<td></td>
<td>Evergreen</td>
<td></td>
<td>0.105</td>
<td>0.210</td>
<td>0.300</td>
</tr>
</tbody>
</table>
Acadian flycatcher HSI model (in development)

- $S_{I_2}$: We fit an inverse logistic function to describe the relationship between Acadian relative density and increasing distance to water. Acadians normally align at least 1 edge of their 1-ha territory along a stream or wetland (Woolfenden et al. 2005).
Acadian flycatcher $S_{I_2}$
Acadian flycatcher HSI model (in development)

- SI$_3$: .....included canopy closure (SI3) because of its strong effect on Acadian flycatcher density (Prather and Smith 2002). ...we utilized a smoothed logistic function to extrapolate between the known break points in the canopy cover-relative density relationship.
Acadian flycatcher SI$_3$
SI₄: Forest patch size was included as a model factor because of the susceptibility of Acadian flycatchers to fragmentation (Robbins et al. 1989) and increasing edge density (Parker et al. 2005). We used a logarithmic function to describe the relatively quick increase in suitability of a forest patch as area increased (Robbins et al. 1989).
Acadian flycatcher HSI model (in development)

- $\text{SI}_5$: This factor accounted for the higher parasitism (Robinson and Robinson 2001) and predation rates (Ford et al. 2001) of increasingly non-forested landscapes. The smoothed logistic function was derived from data collected by Ford et al. (2001) on the difference between sites 80 and 90% forested. The dramatic decline in productivity in increasingly non-forested landscapes was hypothesized from the edge avoidance of this species (Parker et al. 2005) and the absence of Acadians from small fragments (Robbins et al. 1989).
Acadian flycatcher $SI_5$
Acadian flycatcher HSI model (in development)

- $SI_1$: forest type and age-class
- $SI_2$: distance to water
- $SI_3$: canopy closure
- $SI_4$: patch size
- $SI_5$: percent forest cover

Relative density $HSI = \left( (SI_1 \times SI_2 \times SI_3)^{1/3} \right) \times SI_4$
Relative productivity $HSI = SI_5$
GIS-based HSI models

Landscape HSI Modeling for Windows
Version 2.1.1

Developed by USDA Forest Service and the University of Missouri, Columbia
Ovenbird

- Mid-late successional forest species
- Area/edge sensitive

- GIS data layers
  - Forest-type groups
  - Forest/tree age class
  - Ecological land types based on landform
Ovenbird $SI_2$

- If species = pine, then $SI_2 = 0$
- Otherwise, $SI_2 = 1$
Ovenbird $SI_3$

$SI_1$

$SI_3$

30 m

$SI = 0$

$SI = 0.5$

$SI = 1$
HSI = (SI_1 \times SI_2 \times SI_3)^{1/3}
Ecological and landscape effects

- Area sensitivity
- Edge effects
- Interspersion
- Composition
- Juxtaposition of resources
Landscape

HSI MODELING

for Windows
Version 2.1.1

Developed by USDA Forest Service and the University of Missouri, Columbia
Values in SI 1 > 0.0 will be considered a patch.

Patch Size in Hectares

If patch ≥ 0.00 and < 0.41 then SI2 = 0.0

If patch ≥ 0.41 and < 0.43 then SI2 = (0.32 * PATCHSIZE) - 0.13

If patch ≥ 0.43 and < 1000000 then SI2 = 1.0
Decision Rule

If Minimum \( \geq \) 0.0 and \(<\) 0.01

Then SI 3 = 0.5

Else SI 3 = 1.0

Moving Window

- Circle
- Square

Radius in Pixels: [Input Field]

Side of Square: [Input Field]
HSI Equation

\[ \text{POW}((SI1 \times SI2), 0.5) \times SI3 \]

- Write Output File
  - Scale 0.0 - 1.0
  - Scale 0 - 100
Summarizing HSI values for a landscape

- Maps
- Descriptive statistics (mean, median, sum)
- Frequency distributions
- Input to other programs that map home ranges, model population dynamics
Summarizing HSI values for a landscape

The figure shows two cumulative proportion curves for HSI values across two different landscapes. The x-axis represents HSI values ranging from 0.0 to 1.0, while the y-axis shows the cumulative proportion ranging from 0.0 to 1.0.

- **Landscape 1** is represented by a straight line, indicating a consistent proportion across HSI values.
- **Landscape 2** has a more complex curve, showing variations in the cumulative proportion as HSI values increase.

The graph visually demonstrates how HSI values are distributed across these two landscapes, with Landscape 1 having a more uniform distribution compared to Landscape 2.
Summarizing HSI values for a landscape

- Ovenbird: 0.70
- Prairie warbler: 0.02
- Gray squirrel: 0.44
Cerulean warbler HSI

Class 0
Class 0.1-0.25
Class 0.26-0.50
Class 0.51-0.75
Class 0.76-1.0

Alternative 1
Alternative 2
Alternative 3
Alternative 4

Legend:
- Blue: Alternative 1
- Green: Alternative 2
- Yellow: Alternative 3
- Red: Alternative 4
Summarizing HSI values for a landscape

• **Input to other models**
  - Link HSI values to density
    • directly with data
    • map territories
  - Use HSI maps as input to spatially explicit population models
HSI modeling approaches

- Can be developed from existing knowledge or data which can include data, published knowledge, and expert opinion. (+)
- Can use multiple sources of information for SIs or multiple scales within a model. (+)
- Models can be developed for at any desired scale as long as have hypotheses for that scale. (+)
- Can adapt habitat relationships from research studies to available data sources for conservation planning. (+)
HSI modeling approaches

• Predict habitat suitability or quality, not necessarily abundance or density. (+ or -)
• Methods for weighting and combining habitat and landscape factors (suitability indices) are somewhat ad-hoc. (-)
• Models are based on hypotheses (+)
• Models are essentially hypotheses until validated (-)